# GSFC Approach for Proton Effects Characterization of LEDs

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## 1. Purpose

The purpose of the document is to define the requirements for radiation degradation characterization of light emitting diodes (LEDs). Output light and IV curves are measured for LEDs and the collector current is measured for PDs. The test setup should be flexible enough to handle several different kinds of DUTs (device under test).

## 2. DUTs

Most any LED can be tested. In the case were multiple devices are in a single package, the devices must have the individual LEDs electrically and optically accessible and isolated. The individual components must be mounted in a way that it is possible to send unobstructed light from an external laser diode. Also, devices must bonded in such a way that each can be individually powered, i.e. when one device is being supplied power, no others are powered.

## 3. Special Parts Handling

Each device will be labeled with an identification number. This will be logged in the data record book. Normal care should be given to avoid an ESD event. After returning to GSFC the parts will be tagged and stored in the parts library.

## 4. Radiation Source

Proton facilities with known valid dosimetry approaches like UC Davis and TRIUMF. Testing should be done over several energies.

## 5. Test Setup and Approach for Monitoring the DUT Light Output and IV Characterics for LEDs

### 5.1 Light Output Characterization

Figure 1 shows a generic test setup. An external photodetector (EPD) will collect a portion of the light output by the LED under test. An x, y, z , θ (or 4D) stage will be used to move the device between the detector and the proton beam (x and θ are not shown in Figure 1). Figure 2 is a block diagram of the test setup. Figure 3 is a shows the typical DUT card layout.

The test setup allows for monitoring of the light output of an LED at various locations around the LED relative to the emitting surface of the LED. In some cases, a single DUT will contain an emitter and a detector. For such cases, the setup will be capable of measuring both outputs independently (see section 6 for PD setup and measurement approach). The required measurement is a relative change in output values due to radiation exposure, absolute output values are not needed.

The 4D stage will be used to map the output of the LED. One should consider the type of LED, either top or edge emitting, when determining the best position of the LED emitting surface relative to the detector surface of the EPD. The active area of the external detector will large enough so that small movements in LED - EPD relative position has little impact on the measure light. The 4D stage will move the position of the LED relative to the EPD in discrete steps. The EPD output will be recorded as a function of relative position, giving a full mapping of the LED output over position, see Figure 4. The pre-irradiation variation of the EPD output from maximum value position to the minimum value position will be less than a 50%, defining an “area” over which the LED output will be measured. These data are collected after each irradiation.

It is critical that the LED DUT be stabilized before recording values. The stability of the outputs will be verified prior to any data collection.

Repeatability of a measurement after the DUT has been moved between the irradiation and the measurement positions is critical to the success of the test. This requires that experiments be performed to demonstrate the reproducibility of the measurements after movement of the DUT.

For the LED DUT, an injection current annealing study must be completed before characterization over several step-stress levels. One approach is defined below:

1. Irradiate the DUT unbiased to a level where significant degradation has occur. Use the lowest possible drive current when intermediate measurements are made to determine the amount of degradation.
2. Perform an annealing study on the LED which measures the change in the LED output over time using the drive current intended for the full characterization study.
3. During the full characterization study, minimize and record the "on" time of the LED.
4. The total on time for the full characterization study should be short enough so not to impact results.

*5.2 IV curve*
The test setup described above can be used to measure the I-V curve for each LED.

## *6. DUT Biasing, Input and Output Parameters During Post-Irradiation Electrical Chacterization*

*5.1 Light Output Characterization*
The setup will have the ability to vary the LED output by fixing the forward current between some minimum detectable value to the maximum rated value for the LED. For example 0.5, 1,5,10,20,30, 40 mA. The EPD will monitor the light output of the LED DUT at several positions. The light collected by the external detector will be measured after each irradiation at each position, as described above. The peak value of the LED output will be measured, and the relative change in collected light at the peak position will be determined and displayed. The forward current and measured EPD output will be record to a file for each detector position, for later analysis. To allow for real-time analysis, after each exposure, the relative change in peak power will be recorded to a file.

*5.2 IV curve*
The I-V measurements should be made over the full operational range of the LED. The data will be saved to a file for later analysis.

## *7. Hardware*

Parametirc analyzer : HP 4156B
Optical power meter : HP 8153A
Sensor head module for optical head interface HP81533B

## *8. Software*

Customized LABVIEW® software provided a user interface to control signals to the LED DUT and EPD. The software automatically monitored the EPD output and generated a file history.

## ***9. Test Techniques***

The following test procedure will be followed for each device type.

1. Determine the maximum fluence level for the LEDs.
2. Determine the acceptable number of electrical characterizations from the results of the injection current annealing study and the duration of each electrical characterizations. Divide the maximum fluence in step number 1 by the number of steps. This defines the step irradiation levels for component testing. The number of steps can be decreased if necessary, however the minimum is 4.
3. Using an external detector, measure and record the LED output as defined in the sections 5 and 6. Only apply current to the LED that is being sampled. Repeat this measurement a sufficient number of times to show the repeatability of the measurement. (Pre-rad values)
4. Irradiate the LEDs unbiased to the incremental fluence level.
5. Using an external detector, measure and record the LED output as defined in the sections 5 and 6. Only apply current to the LED that is being sampled.
6. Measure I-V curve for each LEDs.
7. Repeat 4, 5 and 6 until the LEDs have degraded to 5% of there original value or to a fluence of $1x10^{12}$ $p/cm^2$

## ***10. Deliveribles***

The following results are required :
1. Repeatability study for each LED.
2. Stability study of LED DUT.
3. Injection current annealing study.
4. The test log that gives the values giving in list below.
5. Data files for : LED mapping
6. IV curves for each DUT
7. Test synopsis

The following values will be recorded in the test log after each step in fluence:
1. run number
2. device description
3. DUT ID
4. proton energy
5. exposure time
6. incremental dose
7. total dose on DUT
8. flux
9. incremental fluence
10. total fluence
11. data file name for LED mapping
12. peak LED output at If = XX
13. forward voltage at If=XX
14. any comments

## SURFACE EMITTING LEDS

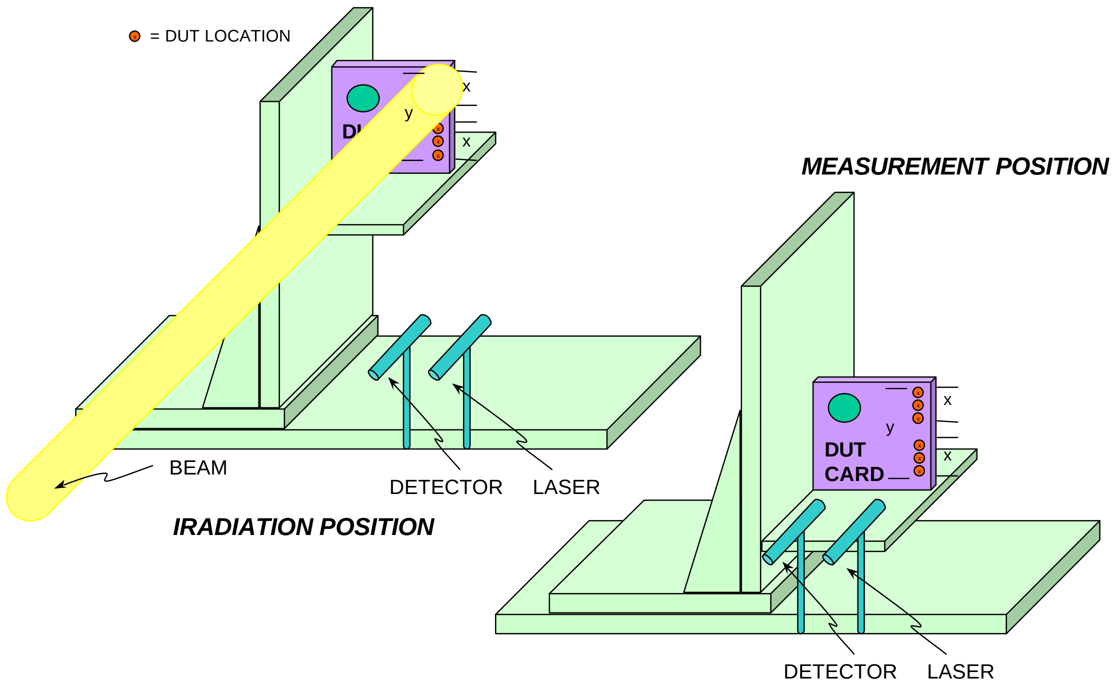



Figure 1

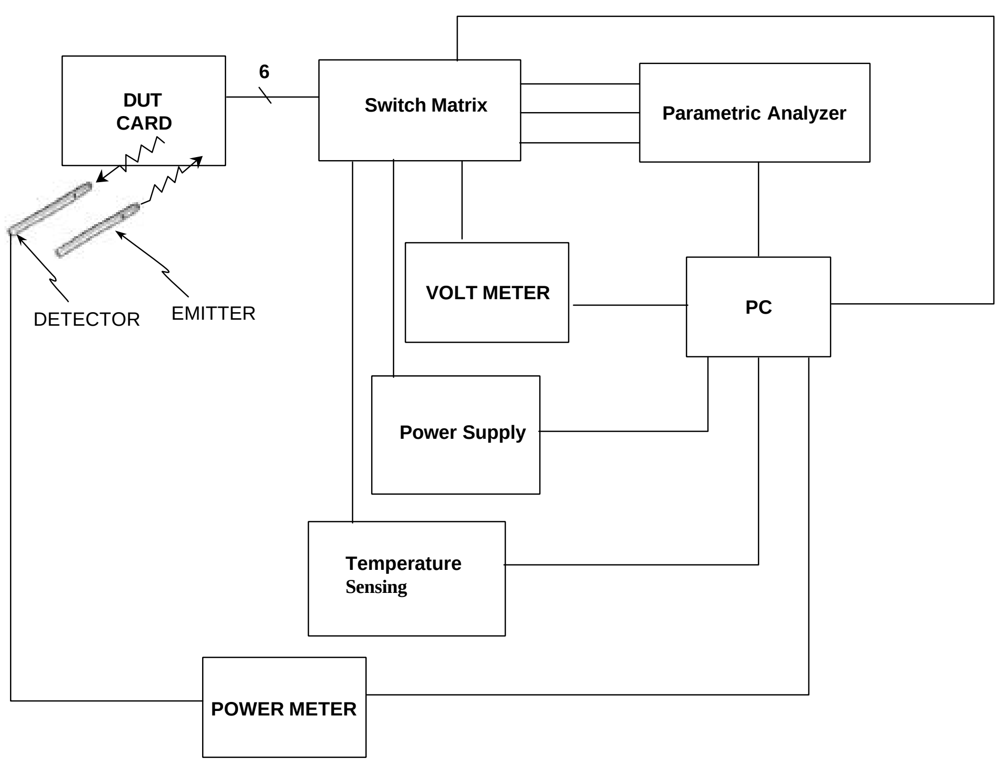
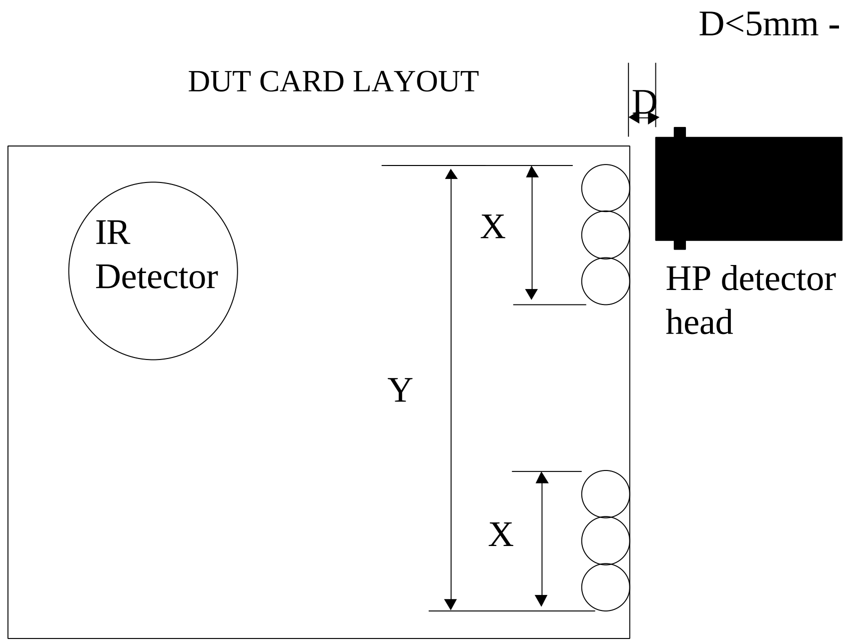



Figure 2




For TRIUMF : X=1.5” , Y=7.5”

Figure 3

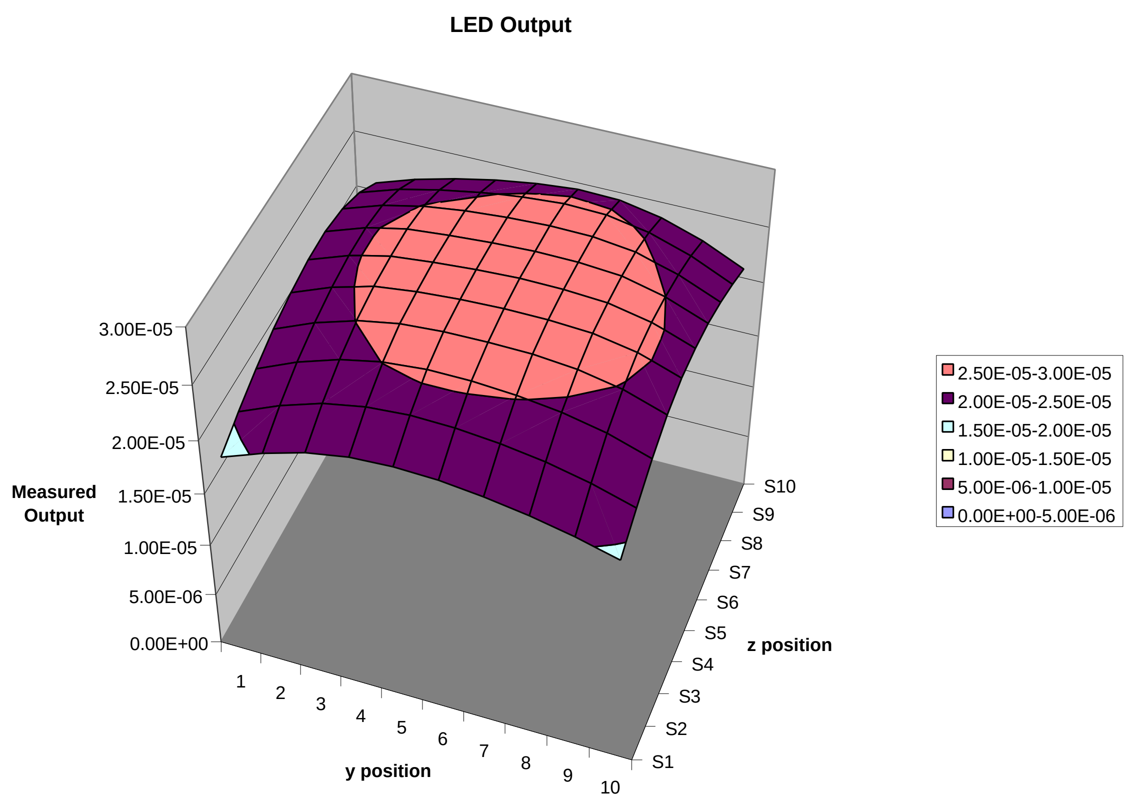



Figure 4